CLAIM + DETAILED DESCRIPTION

[Claim(s)]

[Claim 1] It is III in carrier gas, such as hydrogen and nitrogen. on the substrate crystal which diluted and heated the material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas In the vapor phase epitaxy method including the process which forms p type gallium nitride system compound semiconductor The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor which the temperature of said substrate crystal immediately after the end of crystal growth is 700-degree more than Centigrade, and is characterized by performing cooling less than by the 700-degree Centigrade of said substrate crystal after the end of crystal growth in the atmosphere of the carrier gas except said hydrogen.

[Claim 2] The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor characterized by using at least one inactive gas among a helium, nitrogen, and argon as carrier gas in the vapor phase epitaxy method of a low resistance p type gallium nitride system compound semiconductor according to claim 1.

[Claim 3] In the vapor phase epitaxy method of a low resistance p type gallium nitride system compound semiconductor according to claim 1 The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor characterized by carrying out to carrier gas excluding hydrogen in cooling less than by the 700-degree Centigrade of said substrate crystal after the end of crystal growth in the atmosphere of the gas with which the number of direct combination of nitrogen and hydrogen mixed organic nitrogen compound gas less than 3.

[Claim 4] In the vapor phase epitaxy method of a low resistance p type gallium nitride system compound semiconductor according to claim 3 The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor characterized by using at least one organic ****** among a TASHARU butylamine, horse mackerel-ized ethyl, and dimethylhydrazine as said source of organic nitrogen.

[Claim 5] It is III in carrier gas, such as hydrogen and nitrogen. The material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas are diluted. After forming the required multilayer film containing p type gallium nitride system compound semiconductor layer in vapor phase epitaxy including the process which forms p type gallium nitride system compound semiconductor on the heated substrate crystal, the temperature of said substrate crystal [the state of

700 degree more than Centigrade] The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor characterized by forming n type gallium nitride system compound semiconductor layer as a crystal surface coat, and cooling said substrate crystal after this.

[Claim 6] It is III in carrier gas, such as hydrogen and nitrogen. The material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas are diluted. After forming the required multilayer film containing p type gallium nitride system compound semiconductor layer in vapor phase epitaxy including the process which forms p type gallium nitride system compound semiconductor on the heated substrate crystal, the temperature of said substrate crystal [the state of 700 degree more than Centigrade] The vapor phase epitaxy method of a low resistance p type gallium nitride system compound semiconductor that only As is characterized by only for P forming the n type III-V ******** half conductor layer including the both sides of As and P, and cooling said substrate crystal after this as V ******.

[Claim 7] It is III in carrier gas, such as hydrogen and nitrogen. The material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas are diluted. In vapor phase epitaxy including the process which forms p type gallium nitride system compound semiconductor on the heated substrate crystal When forming a gallium nitride system compound semiconductor diode with p-n junction The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor which is characterized by forming only n type gallium nitride system compound semiconductor after growth of p type gallium nitride system compound semiconductor, and is characterized by the temperature of said substrate crystal at the time of the end of growth being 700 degrees C or more.

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention belongs to the vapor phase epitaxy method of a semiconductor, and belongs to the vapor phase epitaxy method of a low resistance p type gallium nitride system compound semiconductor especially.

[0002]

[Description of the Prior Art] As a method of obtaining p type gallium nitride system compound semiconductor with vapor phase epitaxy conventionally, the method of using a magnesium organic metal as p type dopant materials is common. It is known that magnesium will make the shallowest acceptor level in p type impurities known now.

[0003] However, it is known for hydrogen PASHIBESHON in which the hydrogen contained in the gas in a vapor phase epitaxy process combines with magnesium, and inactivates magnesium electrically that the crystal immediately after growth will become high resistance.

[0004] The temperature profile of a crystal [in / in drawing 6 / the conventional p dope gallium nitride crystal growth process], It is a mimetic diagram showing the kind of gas in a crystal growth room (for example, Japanese Journal of AppliedPhysics vol.30 besides S.Nakamura, No.10A, L1708 to L1711

page, 1991). In drawing 6 , crystal growth temperature is 1030 degrees C. As for hydrogen and gallium materials, the carrier gas under sapphire and growth is [substrate crystal / ammonia and p type dopant materials of trimethylgallium (TMG) and nitrogen materials] cyclo PENTADI ethyl magnesium (CP2 Mg).

[0005] Moreover, substrate cooling after crystal growth is performed in the atmosphere of hydrogen carrier gas and ammonia. In drawing 6 , hydrogen is not taken in by the crystal into the crystal growth in high temperature, but during substrate crystal cooling after the end of growth, hydrogen is spread from the crystal surface, combines with magnesium, and mainly causes hydrogen PASHIBESHON. As a source of hydrogen under substrate crystal cooling, there are hydrogen combined the nitrogen in ammonia and directly and hydrogen of hydrogen carrier gas.

[0006] Drawing 7 shows the layer structure of the light emitting diode crystal manufactured using the p type gallium nitride vapor phase epitaxy method of drawing 6 (for example, Applied Physics Letters64 besides S.Nakamura, No.13, and 1687 to 1689 pages, 1994).

[0007] The light emitting diode crystal consists of the GaN buffer layer 16 on the sapphire board 15, the Si dope n type GaN layer 17, the InGaN active layer 18, the Mg dope p type AlGaN layer 19, and the Mg dope p type GaN layer 20. [p type gallium nitride system compound semiconductor of high resistance by which hydrogen PASHIBESHON was carried out as a result of vapor phase epitaxy] as a technique formed into low resistance The temperature of 400 degrees C or more and the method (see JP,H5-183189,A) of performing a heat annealing at the temperature of about 700 degrees C desirably are proposed in the method (see JP,H3-218625,A) of performing electron irradiation of low energy, and the gaseous phase atmosphere which does not contain a hydrogen atom.

[0008] moreover, as a method for obtaining a low resistance p type, without needing the processing after crystal growth, even when using a vapor phase epitaxy method The method (see JP,H6-232451,A) of growing up magnesium dope gallium nitride on an Inx Aly Ga1-x-y N (0< x<1, 0<=y<1) layer is proposed.

[0009] It is known for the molecule beam epitaxy method for on the other hand growing up only from the materials which do not contain hydrogen that p type gallium nitride of low resistance will be obtained. In this case, nitrogen plasma is used as metal gallium and nitrogen materials as gallium materials.

[0010]

[Problem to be solved by the invention] When performing processing after vapor phase epitaxy, performing low resistance-ization of p type gallium nitride and electron irradiation is used, only the layer of the thickness about the penetration depth of an electron beam (about 0.5 micrometer) can carry out [low ****]-izing, but there is a problem that productivity is low.

[0011] Moreover, when using a heat annealing, the layer thickness which can carry out [low ****]-izing is as thick as about several micrometers, and it excels in productivity, but the nitrogen of gallium nitride ****s and the heat deterioration of a crystal is not avoided by the heat annealing. It is so remarkable that the annealing of the heat deterioration of a crystal is carried out at high temperature.

[0012] Although the gallium nitride system compound semiconductor containing indium reduces the defect of gallium nitride in which it grows up on this, using a comparatively soft thing and obtains a low resistance p type layer by the method currently indicated by JP,H6-232451,A The layer structure

of a crystal is restricted and the effect of the reduction in resistance by this method is not like a heat annealing.

[0013] On the other hand, the molecule beam epitaxy method does not attain to what the crystal obtained now depends on a vapor phase epitaxy method, and the direction of a vapor phase epitaxy method is excellent in mass-production nature.

[0014] So, this invention using the vapor phase epitaxy method for excelling in mass-production nature [have high crystal quality and / p type gallium nitride system compound semiconductor of low resistance] It is in obtaining without needing excessive processes, such as a heat annealing and electron irradiation. It is in offering the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor which obtains p type gallium nitride system compound semiconductor of low resistance by the vapor phase epitaxy method which was excellent in mass-production nature without using processes, such as heat treatment after crystal growth.

[0015]

[Means for solving problem] According to this invention, it is III in carrier gas, such as hydrogen and nitrogen. on the substrate crystal which diluted and heated the material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas In the vapor phase epitaxy method including the process which forms p type gallium nitride system compound semiconductor The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor which the temperature of said substrate crystal immediately after the end of crystal growth is 700-degree more than Centigrade, and is characterized by performing cooling less than by the 700-degree Centigrade of said substrate crystal after the end of crystal growth in the atmosphere of the carrier gas except said hydrogen is acquired.

[0016] Moreover, according to this invention, [cooling less than by the 700 degree Centigrade of said substrate crystal after the end of crystal growth] The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor characterized by carrying out to the carrier gas except hydrogen in the atmosphere of the gas with which the number of direct combination of nitrogen and hydrogen mixed organic nitrogen compound gas less than 3 is acquired.

[0017] Moreover, according to this invention, it is III in carrier gas, such as hydrogen and nitrogen. The material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas are diluted. After forming the required multilayer film containing p type gallium nitride system compound semiconductor layer in vapor phase epitaxy including the process which forms p type gallium nitride system compound semiconductor on the heated substrate crystal, the temperature of said substrate crystal [the state of 700 degree more than Centigrade] n type gallium nitride system compound semiconductor layer is formed as a crystal surface coat, and the vapor phase epitaxy method of the vapor phase epitaxy method low resistance p type gallium nitride system compound semiconductor characterized by cooling said substrate crystal after this is acquired.

[0018] Moreover, according to this invention, it is III in carrier gas, such as hydrogen and nitrogen. The material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas are diluted. After forming the required multilayer film containing p type gallium nitride system compound semiconductor layer in vapor phase epitaxy including the process which forms p type gallium nitride system compound semiconductor on the heated substrate crystal, the temperature of

said substrate crystal [the state of 700 degree more than Centigrade] As V ******, only As forms the n type III-V ******** half conductor layer in which only P includes the both sides of As and P, and the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor characterized by cooling said substrate crystal after this is acquired for it.

[0019] Furthermore, according to this invention, it is III in carrier gas, such as hydrogen and nitrogen. The material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas are diluted. In vapor phase epitaxy including the process which forms p type gallium nitride system compound semiconductor on the heated substrate crystal When forming a gallium nitride system compound semiconductor diode with p-n junction The vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor which is characterized by forming only n type gallium nitride system compound semiconductor after growth of p type gallium nitride system compound semiconductor, and is characterized by the temperature of said substrate crystal at the time of the end of growth being 700 degrees C or more is acquired.

[0020]

[Function] Hydrogen PASHIBESHON in vapor phase epitaxy does not happen easily at 700 crystal temperature or more. Moreover, p type gallium nitride system compound semiconductor by which hydrogen PASHIBESHON was carried out emits hydrogen at the temperature of 400 to 700 degrees or more. It is telling this from 400 degrees for the reduction in resistance of p type layer by the heat annealing in 700 degrees to be possible.

[0021] Therefore, hydrogen PASHIBESHON of the p type gallium nitride which is 700 crystal temperature or more and grew is mainly carried out at the time of cooling after the end of growth. Moreover, in hydrogen PASHIBESHON in this case, although hydrogen is spread from the crystal surface, the hydrogen combined with p type dopant charged in the minus electric charge is charged in positive charge. Therefore, diffusion of hydrogen with positive charge becomes slow in an n-type semiconductor layer without the acceptor charged in the minus electric charge.

[0022] By the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor of this invention, after the crystal growth of p type gallium nitride system compound semiconductor, it is 700 crystal temperature or more, atmosphere gas is changed only to the inactive gas which does not contain hydrogen, such as nitrogen, a helium, and argon, and a crystal is cooled. This prevents that hydrogen is taken in by the crystal during crystal cooling, and hydrogen PASHIBESHON is prevented.

[0023] Moreover, in addition to the method of said description, by the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor of this invention, the number of direct combination of nitrogen and hydrogen adds little organic nitrogen compound gas to the atmosphere gas under crystal cooling from 3. Since such organic nitrogen compound gas has few sources of hydrogen than ammonia, there is little hydrogen PASHIBESHON, and since it can supply active nitrogen, it can control the heat deterioration of the crystal under crystal cooling.

[0024] Moreover, by the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor of this invention, after the crystal growth of p type layer, it is 700 crystal temperature or more, n type gallium nitride system compound semiconductor layer is formed as a crystal surface coat, and a crystal is cooled after this. It controls that hydrogen is spread in the

substrate side rather than a crystal surface coat using hydrogen diffusion of n type layer being slow. A crystal surface coat carries out after [crystal cooling] etching removal.

[0025] Moreover, as said crystal surface coat, the vapor phase epitaxy methods of the low resistance p type gallium nitride system compound semiconductor of this invention are 700 crystal temperature or more, form n type layer which contains arsenic or phosphorus as V ******, and cool a crystal after this. It becomes easy to carry out etching removal of the crystal surface coat alternatively after crystal cooling by this.

[0026] Furthermore, when the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor of this invention forms a p-n diode crystal, after growth of p type gallium nitride system compound semiconductor, they are 700 growth temperature or more, forms only n type gallium nitride system compound semiconductor, and cools a crystal after this. It controls that hydrogen is spread in p type layer using hydrogen diffusion of n type layer being slow. In this case, etching after crystal cooling becomes unnecessary.

[0027]

[Mode for carrying out the invention] [the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor in the example of a form of the 1st or operation of five of this invention explained below] It is III in carrier gas, such as hydrogen and nitrogen. The material gas of a ****** compound, the material gas of a nitrogen compound, and p type dopant gas are diluted, and the process which forms p type gallium nitride system compound semiconductor on the substrate crystal which heated is included.

[0028] The temperature of the substrate crystal immediately after the end of crystal growth is 700-degree more than Centigrade, and, as for the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor in the example of a form of the 1st operation of this invention, cooling less than by the 700-degree Centigrade of the substrate crystal after the end of crystal growth is performed in the atmosphere of the carrier gas which does not contain hydrogen. As carrier gas, the inactive gas which does not contain hydrogen, such as a helium, nitrogen, and argon, is used.

[0029] Drawing 1 shows the mimetic diagram which expresses the kind of gas in a crystal growth room as the temperature profile of the substrate crystal in the gaseous phase crystal growth process which starts the vapor phase epitaxy method of a low resistance p type gallium nitride system compound semiconductor as an example of a form of operation of the 1st of this invention. In drawing 1 , the degree of crystal base board temperature at the time of the crystal growth containing p type gallium nitride is 1030 degrees. At the time of crystal base board cooling after the end of crystal growth, in 700 degrees or more, it carries out in the gaseous phase atmosphere of hydrogen carrier gas and ammonia, and atmosphere gas is changed only to nitrogen gas in 700 degrees. The crystal surface receives heat deterioration during cooling of 700 or less degrees. Etching removal of the gallium nitride system compound semiconductor layer of the crystal surface coat which carried out heat deterioration is carried out after cooling a crystal.

[0030] Since the temperature at the time of substrate crystal cooling in the ammonia atmosphere in crystal growth and after the end of crystal growth is more than the annealing temperature (400 to 700 degree C) in JP,H5-183189,A of the conventional example, hydrogen PASHIBESHON does not

happen at this time. Since atmosphere gas is only nitrogen at the time of substrate crystal cooling at 700 or less degrees, hydrogen is not spread from the crystal surface. However, a crystal surface coat receives heat deterioration during cooling. If etching removal of the gallium nitride system compound semiconductor layer of the crystal surface coat which carried out heat deterioration is carried out after cooling a crystal, the crystal which had desired layer structure and had a low resistance p type layer will be obtained.

[0031] [the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor in the example of a form of operation of the 2nd of this invention] In the vapor phase epitaxy method of the example of a form the 1st operation, the number of direct combination of nitrogen and hydrogen carries out to the carrier gas which does not include cooling less than by the 700-degree Centigrade of the substrate crystal after the end of crystal growth for hydrogen in the atmosphere of the gas which mixed organic nitrogen compound gas less than 3. As a source of organic nitrogen, a TASHARU butylamine, horse mackerel-ized ethyl, dimethylhydrazine, etc. are used, for example.

[0032] Drawing 2 is a mimetic diagram which expresses the kind of gas in a crystal growth room as the temperature profile of the substrate crystal in the gaseous phase crystal growth process concerning the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor of the example of a form operation of the 2nd of this invention. In drawing 2 , the degree of crystal base board temperature at the time of the crystal growth containing p type gallium nitride is 1030 degrees. At the time of crystal base board cooling after the end of crystal growth, in 700 degrees or more, it carries out in the gaseous phase atmosphere of hydrogen carrier gas and ammonia, atmosphere gas is changed to the mixed gas of nitrogen gas and dimethylhydrazine in 700 degrees, and a substrate crystal is cooled to room temperature.

[0033] In the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor of the example of a form the 2nd operation, [the temperature at the time of substrate crystal cooling in the ammonia atmosphere in crystal growth and after the end of crystal growth] Since it is more than the annealing temperature (400 to 700 degree C) in JP,H5-183189,A of the conventional example, hydrogen PASHIBESHON does not happen at this time. Since atmosphere gas is only nitrogen and dimethylhydrazine at the time of substrate crystal cooling at 700 or less degrees, there is little hydrogen PASHIBESHON compared with cooling in ammonia atmosphere. The number of hydrogen-nitrogen direct combination of dimethylhydrazine is 2, and is because it is small compared with 3 in the case of ammonia.

[0034] Moreover, in order to cool a crystal in the active nitrogen atmosphere acquired by the thermal cracking of dimethylhydrazine unlike the example of a form of the 1st operation, the heat deterioration on the surface of a crystal is controlled. In the example of a form of the 2nd operation, it is not dependent on the layer structure of a desired crystal, and productivity is high. Although as good a crystal as what uses ammonia incidentally is not obtained with the vapor phase epitaxy of the gallium nitride compound semiconductor using the source of organic nitrogen, it is satisfactory when using only for surface protection.

[0035] [the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor in the example of a form of operation of the 3rd of this invention] After

forming the required multilayer film containing p type gallium nitride system compound semiconductor layer, it is in the state of 700-degree more than Centigrade, and the temperature of a substrate crystal forms n type gallium nitride system compound semiconductor layer as a crystal surface coat, and cools a substrate crystal after this.

[0036] Drawing 3 shows the layer structure of the light emitting diode crystal created using the gaseous phase crystal growth process concerning the low resistance p type gallium nitride system compound semiconductor in the example of a form of operation of the 3rd of this invention. In drawing 3 , the light emitting diode crystal consists of the GaN buffer layer 2 on the sapphire board 1, the Si dope n type GaN layer 3, the InGaN active layer 4, the Mg dope p type AlGaN layer 5, the Mg dope p type GaN layer 6, and the Si dope n type GaN crystal surface coat 7. The degree of crystal base board temperature at the time of the crystal growth of the Mg dope p type AlGaN layer 5, the Mg dope p type GaN layer 6, and the Si dope n type GaN crystal surface coat 7 is 1030 degrees. The cooling process of the conventional technology is used at the time of cooling after the end of crystal growth. In this vapor phase epitaxy method, you may use the cooling process explained in the 1st and 2nd examples of an embodiment. Etching removal of the crystal surface coat 7 is carried out after cooling a crystal to room temperature.

[0037] Since the temperature at the time of the end of crystal growth of the Si dope n type GaN crystal surface coat 7 shown in drawing 3 is more than the annealing temperature (400 to 700 degree C) in JP,H5-183189,A of the conventional example, hydrogen PASHIBESHON does not happen by this point in time. Although hydrogen is spread from the crystal surface at the time of cooling after the end of crystal growth, the hydrogen combined with the acceptor (Mg) charged in the minus electric charge is charged in positive charge. Since diffusion of hydrogen with positive charge becomes slow in Si dope n-type semiconductor layer 7 without the acceptor charged in the minus electric charge, Hydrogen with positive charge is accumulated in the Si dope n type GaN layer 7 of the crystal outermost surface, and hydrogen PASHIBESHON of the Mg dope p type AlGaN layer 5 and the Mg dope p type GaN layer 6 is not carried out. After cooling a crystal to room temperature, if etching removal of the crystal surface coat is carried out, the crystal which had desired layer structure and had a low resistance p type layer will be obtained.

[0038] [the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor in the example of a form of operation of the 4th of this invention] After forming the required multilayer film containing p type gallium nitride system compound semiconductor layer, it is in the state of 700-degree more than Centigrade, and only As forms the n type III-V ******** half conductor layer in which only P includes the both sides of As and P as V ******, and the temperature of a substrate crystal cools said substrate crystal after this.

[0039] Drawing 4 shows the layer structure of the light emitting diode crystal created using the gaseous phase crystal growth process concerning the low resistance p type gallium nitride system compound semiconductor in the example of a form of the 4th operation. In drawing 4 , the light emitting diode crystal consists of the GaN buffer layer 2 on the sapphire board 1, the Si dope n type GaN layer 3, the InGaN active layer 4, the Mg dope p type AlGaN layer 5, the Mg dope p type GaN layer 6, and the Si dope n type GaAs crystal surface coat 8. The degree of crystal base board temperature at the time of the crystal growth of the Mg dope p type AlGaN layer 5 and the Mg dope p

type GaN layer 6 is 1030 degrees. The degree of crystal base board temperature is lowered to 800 degrees after the crystal growth of the Mg dope p type AlGaN layer 5 and the Mg dope p type GaN layer 6, and the Si dope n type GaAs crystal surface coat 8 is formed. The cooling process of the conventional technology is used at the time of cooling after the end of crystal growth. Moreover, you may use the cooling process used for the example of a form of the 1st and operation of the 2nd of this invention. Etching removal of the crystal surface coat of the Mg dope p type AlGaN layer 5 and the Mg dope p type GaN layer 6 is carried out after cooling a crystal to room temperature.

[0040] In the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor of the example of a form the 4th operation, the crystal surface coat in the example of a form of the 3rd operation has placed and replaced the Si dope n type GaAs layer 8. Since the grating constant of GaAs is larger than a gallium nitride system compound semiconductor about 15%, the crystal surface coat of the Si dope n type GaAs layer 8 becomes many crystals or the shape of amorphous. By this invention, since temperature when the crystal growth containing a crystal surface coat is completed is more than the annealing temperature (400 to 700 degree C) in JP,H5-183189,A of the conventional example, hydrogen PASHIBESHON does not happen at the time to crystal surface coat formation. At the time of crystal cooling after the end of crystal growth, hydrogen PASHIBESHON of the Mg dope p type AlGaN layer 5 and the Mg dope p type GaN layer 6 can be prevented by the same principle as the example of a form of the 3rd operation. If etching removal of the Si dope n type GaAs layer 8 of a crystal surface coat is carried out for a crystal after cooling to room temperature, the crystal which had desired layer structure and had a low resistance p type layer will be obtained. It does not depend for this method on the layer structure of a desired crystal. Moreover, although the gallium nitride system compound semiconductor cannot carry out wet etching easily, since GaAs can be easily etched with sulfuric acid-hydrogen-peroxide-solution solution, it can remove easily the Si dope n type GaAs layer 8 of a crystal surface coat alternatively. In addition, although a crystal surface coat is GaAs in the example of a form of the 4th operation, any of the compound semiconductor which contains As or P as V ******, such as InP, GaP, InGaAs, and InGaAsP, are sufficient as a crystal surface coat.

[0041] [the vapor phase epitaxy method of the low resistance p type gallium nitride system compound semiconductor in the example of a form of operation of the 5th of this invention] When forming a gallium nitride system compound semiconductor diode with p-n junction, only n type gallium nitride system compound semiconductor is formed after growth of p type gallium nitride system compound semiconductor, and the substrate crystal temperature at the time of the end of growth may be 700 degrees C or more.

[0042] Drawing 5 shows the layer structure of the light emitting diode crystal created using the gaseous phase crystal growth process concerning the low resistance p type gallium nitride system compound semiconductor in the example of a form of operation of the 5th of this invention.